

I CLAIM:

1. In a momentum management system for attitude control of a spacecraft, the system having:

a housing to be fixed to the spacecraft;

5 a momentum wheel rotor in the housing and rotatable about a rotor axis for  
storing angular momentum;

a gimbal assembly mounting the rotor in the housing;

a drive having an output rotatable about a drive axis, the output being coupled to the rotor for rotating the rotor; and

10 a torque generation device for imparting torque to the rotor about axes  
orthogonal to the drive axis,

the improvement wherein:

the gimbal assembly comprises a gimbal ring coupling the drive output to the rotor; and

15 the gimbal ring includes respective flexure joints connecting the gimbal ring to the drive and the rotor, the flexure joints being configured to permit the rotor to tilt about two flexure axes orthogonal to the drive axis, to incline the rotor axis through a range of angles from about 0 degrees to about 7 degrees with respect to the drive axis under the control of said torque generation device.

20      2.      A momentum management system according to claim 1, wherein each flexure joint comprises a two resilient, non-parallel webs having respective ring ends connected to a body of the gimbal ring and respective mounting ends connected to one of the drive and the rotor.

3. A momentum management system according to claim 2, further comprising a  
25 launch restraint system to limit movement of the rotor along the drive axis, the launch  
restraint system including a stop mounted on the drive output and a cage mounted on  
the rotor and surrounding the stop.

4. A momentum management system according to claim 3, wherein the launch restraint system further includes deflection stops adjacent opposite sides of each web of each flexure for limiting deflection of the webs.

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5. A momentum management system for attitude control of a spacecraft, the system having:

a housing;

a rotor drive having an output rotatable about a drive axis, the drive axis being fixed with respect to the housing;

a gimbal assembly connected to the drive output;

10 a momentum wheel rotor rotatable about a rotor axis for storing angular momentum, the rotor being mounted on the gimbal to be rotated about the drive axis by the rotor drive and for tilting movement about transverse axes orthogonal to the drive axis;

a torque generation device for tilting the rotor about the transverse axes; and

15 a sensor for measuring the rotation of the rotor about the rotor axis, the sensor comprising:

a part spherical surface on the momentum wheel rotor;

a pattern formed on the part spherical surface; and

20 a sensor mounted at a fixed position relative to the housing and positioned adjacent the part spherical surface for detecting the passage of the pattern past the sensor with rotation of the rotor.

6. A momentum management system according to claim 5, wherein the pattern has a leading edge and a trailing edge spaced apart circumferentially of the part spherical surface by a distance that varies with position along the rotor axis and the sensor detects the leading and trailing edges of the pattern whereby the sensor comprises a tilt sensor for measuring the amount of tilt of the rotor about the transverse axes.

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8. A momentum management system for attitude control of a spacecraft, the system having:

- a momentum wheel rotor rotatable about a rotor axis for storing angular momentum, the rotor being mounted on the gimbal to be rotated by the drive and for rotation about transverse axes orthogonal to the drive axis;

- an inner permanent magnet annulus mounted on the rotor, concentric with the rotor axis and with poles spaced apart by a pole spacing dimension along the rotor axis;

- a torque coil annulus between the inner and outer permanent magnet annuli and concentric with the drive axis, the torque coil annulus having a core with a dimension axially of the drive axis that is greater than the pole spacing dimension.

10. A momentum management system according to claim 9 including a thermal  
25 sensor within the ferromagnetic cage for measuring the temperature of the inner and  
outer permanent magnet annuli.

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a gimbal assembly connected to the drive output;

a momentum wheel rotor rotatable about a rotor axis for storing angular momentum, the rotor being mounted on the gimbal to be rotated by the drive and for rotation about transverse axes orthogonal to the drive axis;

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inner and outer permanent magnet annuli mounted on the rotor, concentric with the rotor axis and spaced apart radially with respect to the rotor axis;

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a ferromagnetic cage mounted on the rotor and surrounding the inner and outer permanent magnet annuli and the torque coil annulus.

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14. A momentum management system (10) according to claim 13 wherein the cage has an inner surface coated with a high emissivity material.

15. In a method of manufacturing a gimbal assembly, comprising:

(i) providing a substantially cylindrical inner ring;

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(iii) mounting the inner ring coaxially within the outer ring;



comprising removing material from axially opposite ends of the ring so as to maintain the centre of mass of the ring at the intersection of the ring axis and the flexure axes.

21. A momentum management system for attitude control of a spacecraft, the system having:

5 a rotor drive having an output rotatable about a drive axis at a variable drive output speed;

a gimbal assembly connected to the drive output;

a momentum wheel rotor rotatable about a rotor axis for storing angular momentum, the rotor being mounted on the gimbal to be rotated about the drive axis  
10 by the rotor drive and for tilting movement about transverse axes orthogonal to the drive axis;

a torque generation device for tilting the rotor about the transverse axes;

a sensor for measuring the speed of the rotor rotation about the rotor axis and generating a sensor output representative of said speed; and

15 drive control means responsive to the sensor output for varying the drive output speed so as to maintain the speed of the rotor rotation substantially constant.

22. A combined momentum management and rate sensor apparatus for spacecraft attitude control, comprising:

20 a rotor drive having an output rotatable about a drive axis at a variable drive output speed;

a gimbal assembly connected to the drive output;

a momentum wheel rotor rotatable about a rotor axis for storing angular momentum, the rotor being mounted on the gimbal to be rotated about the drive axis  
25 by the rotor drive and for tilting rotation about transverse axes orthogonal to the drive axis;

a torque generation device for rotating the momentum wheel rotor about the transverse axes to vary the spacecraft attitude;

a sensor for measuring the rotor rotation about the transverse axes, and for generating a sensor output representative of the measured rotations;

a processor for receiving the sensor output and calculating from the sensor output spacecraft rotation rates about said transverse axes; and

5 an attitude control for controlling operation of the torque generation device in accordance with the rotation rates calculated by the processor.

23. A combined momentum management and rate sensor apparatus according to claim 22 wherein the sensor comprises means for measuring the rotor speed of rotation about the rotor axis.

10 24. A combined momentum management and rate sensor apparatus according to claim 23 wherein the processor includes notch filters for filtering frequencies from the sensor output equal to the rotor speed of rotation and twice the rotor speed of rotation.